

Effects of Sample Storage on Biosolids Compost Stability and Maturity Evaluation

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ABSTRACT

Compost stability and maturity are important parameters of compost quality. To date, nearly all compost characterization has been performed using samples freshly collected because sample storage can affect compost stability and maturity evaluation. However, sample preservation is sometimes necessary, especially for scientific research purposes. There is little information available on the effects of sample storage on compost stability and maturity. Samples of biosolids compost with different levels of stability and maturity were collected from four compost facilities in Florida (referred to as Register, Winslow, Sunset, and Meadow). Comparisons of CO₂ evolution, seed germination rate, and water-soluble organic carbon (WSOC) were made between fresh samples with short storage at 4°C for less than 1 wk and air-dried or frozen compost samples stored for 1 yr. The effects of storage (air-dry or frozen) on the measured parameters depended on compost stability and maturity and on the compost material source. Frozen storage reduced the peak CO₂ evolution of Register samples by 12 to 29%, while accumulated CO₂ evolution was reduced by 43 to 64% and 110 to 277% with air-dry and frozen storage, respectively. The storage effect on CO₂ evolution with more stable compost was inconsistent. Storage did not affect compost phytotoxicity, except for samples from the Sunset facility. Air-drying reduced the WSOC by up to 35%, and freezing increased it by up to 34%, while both storage methods had no significant effect on samples of low WSOC. Despite all these variations, WSOC had a significant and consistent relation to CO₂ evolution and seed germination rates with R^2 of 0.78 and 0.57, respectively, regardless of storage methods.

LAND application of composted biosolids is a promising alternative of biosolids disposal (Goldstein and Steuteville, 1996). Compost stability and maturity are important factors affecting the successful application of compost for agricultural purposes (Inbar et al., 1990; Mathur et al., 1993). As such, numerous studies have been conducted to evaluate compost stability and maturity (Bernal et al., 1998; Henry and Harrison, 1996; Mathur et al., 1993). Fresh compost samples with minimum storage time have often been used in those studies due to the concern that sample storage may affect compost stability and maturity. However, in reality, sampling and analysis cannot always be carried out simultaneously. As a result, there is a need to study the effects of sample storage on compost stability and maturity, and develop a satisfactory method to preserve compost samples for stability and maturity evaluation.

To date, there has been little work done to study the storage effect on compost stability and maturity. However, relevant information is available from the related study of storage effects on soil analyses. The

soil storage method depends on the parameters to be analyzed. For chemical analysis, air-drying of soil samples is the most common practice (Bates, 1993), despite the concern that the drying and rewetting of soil may significantly alter the results of some chemical analyses (Rayment, 1993; Slattery and Burnett, 1992), especially analyses involving soil solution chemistry (Walworth, 1992). For microbial analysis, refrigeration and freezing field-moist soil are the most commonly used methods (Stenberg et al., 1998). Air-dry samples are considered least suitable because the air-drying process alters microbial metabolism and reduces the diversity of microbial species (Zelles et al., 1991). Refrigeration of samples at 2 to 4°C is commonly recommended for analysis on soils with short-term storage of less than 90 d (Brohon et al., 1999). However, a slow depletion of the available substrate is expected due to the ongoing microbial activity (Coxson and Parkinson, 1987) that occurs even with refrigeration. The effect of freezing on microbial activity is not as well defined. Freezing reduces microbial activity by cell lysis during ice formation (MacLeod and Calcott, 1976). However, the freezing and subsequent thawing of soil can also cause improved aggregate dispersal (Winter et al., 1994). This may reduce the physical protection of organic matter and microbial biomass, thus enhancing microbial activity (Hasink, 1995). The effects of frozen storage on sample analysis depend on the types of soil samples used and microbial parameters analyzed. Winter et al. (1994) discouraged the use of sample freezing for microbial biomass C analysis. Although no significant detrimental effects were actually observed, they believed that the effects of freezing were being masked by improvements in extraction efficiency with frozen samples. Stenberg et al. (1998) concluded that storage at -20°C for 13 mo had no effect on the microflora in annually frozen soils. The United States Composting Council (2001) recommended 4°C for short-term storage of less than 2 wk, and -4°C for long-term storage of compost samples for biological analysis, including compost stability and maturity evaluation. However, the maximum time that samples can be stored under this condition was not specified.

Compost stability and maturity are comprehensive properties indicating the degree of organic matter decomposition and potential of phytotoxicity caused by insufficient composting. Currently, there is no official definition of the two terms. However, among the numerous chemical and biological parameters used to evaluate compost stability and maturity, the most widely accepted are the microbial respiration test based on O₂ uptake or CO₂ evolution (Chen and Inbar, 1993; Ianotti

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Abbreviations: WSOC, water-soluble organic carbon.

et al., 1994; Lasaridi and Stentiford, 1998) and the seed germination test for phytotoxicity (Frost et al., 1992; Keeling et al., 1994; Tiquia et al., 1996; Zucconi et al., 1981). Compost stability and maturity can be operationally defined by the respiration activity of compost and the phytotoxicity property of compost, respectively (Wu et al., 2000). Since composting is a microbial process, compost stability and maturity are the results of microbial activity. We hypothesize that the chemical composition and organic matter decomposition status of compost will play an important role in determining microbial activity. During storage, if microbial activity is minimal, the compost stability and maturity status should remain unchanged, unless there is significant disruption of the physical and chemical properties of compost samples. As a result, preserved compost samples can, in principle, be used for compost stability and maturity tests.

Except for extremely mature compost, most compost has a relatively high organic matter content with potentially available organic carbon and nutrients that will support relatively high microbial populations or activity. Thus, storing compost at 2 to 4°C for a long time may significantly change its compost chemistry, especially for the less stable or less mature composts, due to the ongoing microbial activity. It is desirable to completely stop all microbial activity during long-term storage. We saw visible fungal colonies in previous samples stored for 60 to 90 d at 4°C, which indicated that refrigeration was not a suitable method for storing samples for up to 1 yr. As a result, the refrigeration method of storage was not chosen for this study. Air-drying and freezing storage methods were selected to minimize the microbial activity during the long period of sample storage.

The objective of this study was to compare the effects of the two sample storage methods on compost stability and maturity. Compost samples were stored at room temperature (24 ± 2°C) after air-drying or were stored frozen (-18 to -20°C) for a period of 12 mo. Test results from stored compost samples using these methods were compared with those of fresh compost samples. Three methods of evaluating compost stability and maturity were tested: the respiration activity test based on CO₂

evolution, the seed germination rate test for phytotoxicity, and a WSOC test.

MATERIALS AND METHODS

Compost Sample Collection, Preparation, and Characterization

Biosolids compost samples were collected from four full-scale composting facilities in Florida (referred to as Register, Winslow, Sunset, and Meadow). The compositions of feedstock differed among facilities but were relatively consistent within an individual facility. Two or three samples were collected at each facility depending on the curing time of the compost (Table 1). For each sample, three places (approximately evenly distributed along the pile or bed of the same curing time) were selected. At each place, a hole was made and samples near the top, middle, and bottom of the pile were collected and combined. Compost on the surface and very bottom was avoided. The samples taken from the different places at each pile or bed were then combined. Curing piles from each facility had different heights, thus the depths at which samples were collected were different too. Collected samples were placed in low-density polyethylene bags, packed on ice in a cooler, and shipped to the lab the same day. Upon arrival at the lab, the samples were sieved through a 9.5-mm screen to remove large particles. A portion of screened sample was kept refrigerated at 4°C. A subsample was air-dried at 45°C and stored in a sealed plastic bag at room temperature. Another subsample was sealed in a plastic bag and stored at -20°C in a freezer. Since the refrigeration storage at 4°C was less than 1 wk, these samples were considered "fresh" compared with the air-dried and frozen samples, which were subsequently stored for 1 yr. Three parameters of compost stability and maturity (i.e., CO₂ evolution, phytotoxicity, and WSOC) were performed on both the "fresh" and stored samples. Samples used for each evaluation had the same storage time of 1 yr. Fresh samples were used to determine moisture content, water holding capacity, pH, and electrical conductivity (EC) (Table 1). A subsample of air-dried sample was ground to pass through a 2-mm screen for volatile solid, total N, and organic C analysis (Table 1). All analyses were carried out in triplicate. Moisture content was determined as weight loss upon drying at 105°C in an oven for 24 h. Water holding capacity was estimated at 0.01 MPa (10⁶ Pa) pressure (Cassel and Nielsen, 1982). Electrical conductivity and pH were determined from a compost-water extract solution (1:10) using an

Table 1. Selected physical and chemical properties of tested biosolids compost samples.

Compost method	Other wastes and amendments	Sample	Curing d	Moisture content	WHC [†]	pH (water)	Electrical conductivity	Volatile solids	TKN [‡]	Organic carbon	C to N ratio
				g kg ⁻¹							
Force-aerated windrow	food waste, yard waste, animal manure, & wood chips	Register-1	0	654	1148	5.8	0.48	681	28.4	398	14
		Register-2	7	585	1116	7.0	0.45	737	25.8	413	16
		Register-3	30	507	991	8.4	0.38	668	26.1	392	15
In vessel (IPS§)	ground yard waste	Winslow-1	0	693	1279	8.4	0.18	562	16.8	319	19
		Winslow-2	7	601	1075	8.7	0.19	614	18.0	342	19
		Winslow-3	30	1101	1312	8.8	0.16	598	18.2	346	19
In vessel (PURAC¶)	sawdust	Sunset-1	0	1039	1468	7.3	0.13	914	13.6	517	38
		Sunset-3	14	1078	1423	7.8	0.14	916	14.1	522	37
		Sunset-5	35	914	1428	7.0	0.14	902	13.8	511	37
Windrow	yard waste	Meadow-1	30	527	669	6.4	0.13	221	11.3	124	11
		Meadow-2	90	435	473	6.0	0.09	164	6.9	90	13

[†] Water-holding capacity.

[‡] Total Kjeldahl nitrogen.

[§] Agitated bed technology by International Process Systems (USFilter, Sturbridge, MA).

[¶] Closed in-vessel composting system developed by PURAC Engineering (Wilmington, DE).

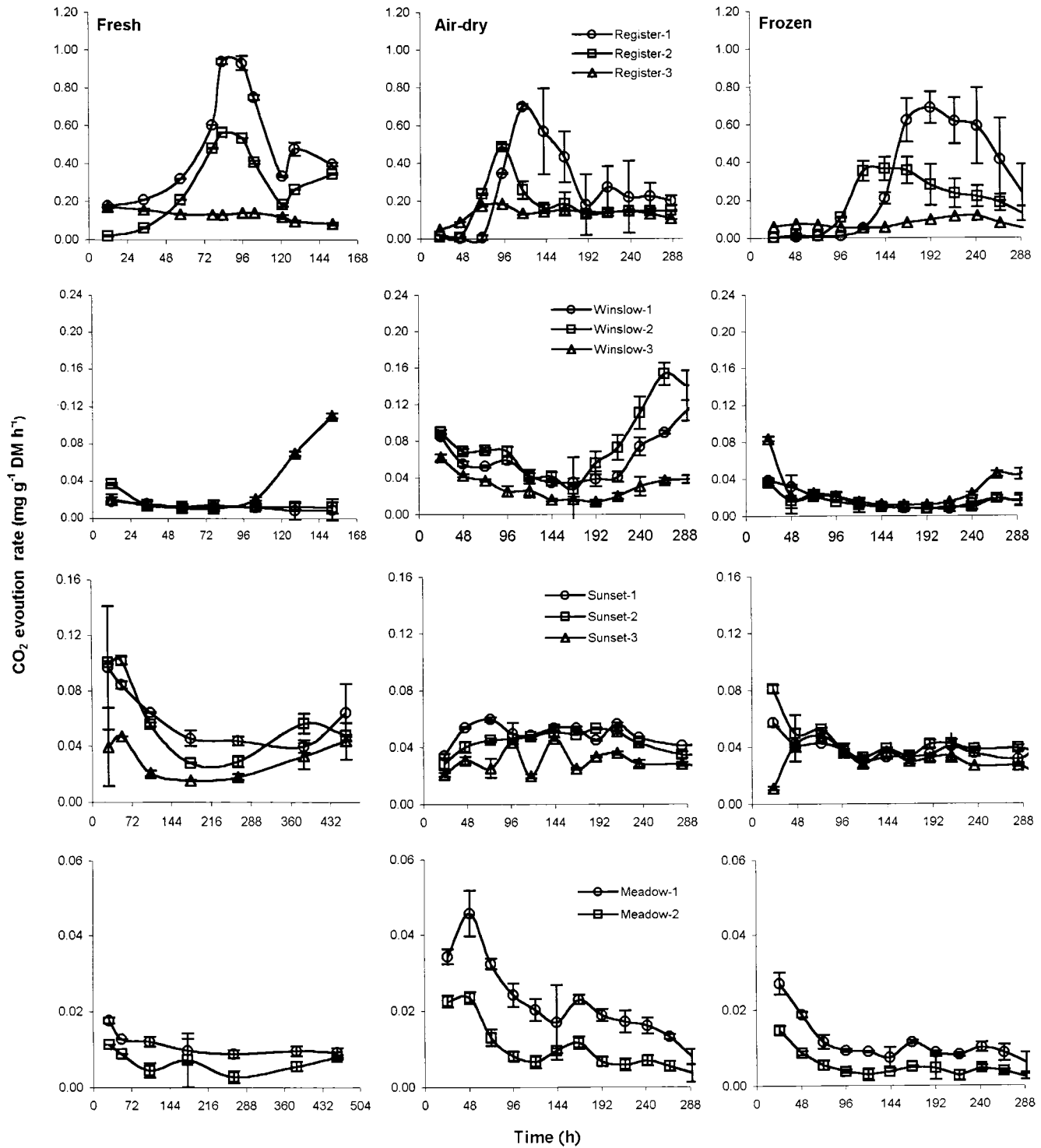


Fig. 1. Effects of sample storage on CO₂ evolution rate (mg CO₂ g⁻¹ dry matter h⁻¹) of 11 compost samples. Error bars represent the standard deviation of 3 replicates. DM = dry matter.

Accumet (Rancho Palos Verdes, CA) pH/Conductivity meter (Model 20). Total volatile solids (TVS) were determined as sample weight loss (previously oven-dried at 105°C) upon ashing at 550°C for 4 h in a muffle furnace. Total organic carbon was calculated by multiplying the TVS values by 1.76 (Nelson and Sommers, 1982). Air-dried and ground compost samples were digested for total Kjeldahl nitrogen (TKN) as total nitrogen because these samples had low (<20 mg kg⁻¹)

or no nitrate (Bremner and Mulvaney, 1982). Total Kjeldahl N was analyzed using an Alpkem (College Station, TX) air-segmented, continuous-flow, automated spectrophotometer.

Compost Stability and Maturity Evaluation

Compost stability was measured based on CO₂ evolution using a modified procedure of Iannotti et al. (1994). Approx-

Table 2. Peak CO₂ evolution rates of fresh, air-dry, and frozen compost samples.†

Sample	Fresh	Air-dry	Frozen
	g CO ₂ kg ⁻¹ dry matter h ⁻¹		
Register-1	0.96 ± 0.02a‡	0.77 ± 0.03b	0.74 ± 0.03c
Register-2	0.48 ± 0.00a	0.49 ± 0.01a	0.42 ± 0.06b
Register-3	0.17 ± 0.00a	0.18 ± 0.01a	0.12 ± 0.01b
Winslow-1	0.11 ± 0.01a	0.08 ± 0.00a	0.04 ± 0.00b
Winslow-2	0.02 ± 0.00b	0.09 ± 0.00a	0.04 ± 0.00b
Winslow-3	0.04 ± 0.01b	0.06 ± 0.00ab	0.08 ± 0.00a
Sunset-1	0.09 ± 0.00a	0.06 ± 0.00a	0.06 ± 0.00a
Sunset-3	0.10 ± 0.00a	0.05 ± 0.00b	0.07 ± 0.02a
Sunset-5	0.05 ± 0.00a	0.05 ± 0.01a	0.05 ± 0.00a
Meadow-1	0.02 ± 0.00a	0.05 ± 0.01a	0.03 ± 0.00a
Meadow-2	0.01 ± 0.00a	0.02 ± 0.00a	0.01 ± 0.00a
Overall means	0.20 ± 0.29a	0.18 ± 0.24b	0.16 ± 0.23c

† Measurements were taken at 24 ± 2°C and 60% of moisture content in the lab during a period of incubation for <14 d.

‡ One standard deviation of three replicates; means of different treatments on each sample (same row) that are followed by the same letter are not significantly different ($\alpha = 0.05$) using Duncan's Multiple Range Test.

mately 10 g of screened sample with moisture content adjusted to 60% was added to a 0.5-L sealed vessel along with a beaker containing a known volume of 0.5 M NaOH. The samples were incubated at room temperature (24 ± 2°C) for at least 7 d. During the incubation, the released CO₂ was captured by the NaOH solution. The NaOH solution was collected every 12 to 24 h based on the respiration activity (samples were allowed to aerate for 30 min at each collection time). The evolved CO₂ was determined by titration of the NaOH solution. Peak CO₂ evolution rate was obtained by averaging the highest CO₂ evolution rate points of the three replicates for each compost sample.

Compost maturity was determined using a modified phytotoxicity test employing seed germination (Zuconi et al., 1981). Two pieces of No. 2 Whatman filter paper were placed inside a 15- × 100-mm sterilized, disposable petri dish. The filter paper was wetted with 9 mL of a compost-water extract solution (1:10) and 30 tomato (*Lycopersicon esculentum* L.) seeds were then placed on the paper. Deionized distilled water (DDW) was used as a control. The petri dishes were sealed with Parafilm to minimize water loss while allowing air penetration and were kept at room temperature in the dark. At the end of 4 d, the percentage of seed germination in the compost extract was compared with that of the water control. A preliminary test on the effects of soluble salts on tomato seed germination using CaCl₂ and NaCl solutions revealed no inhibition of seed germination when solution electrical conductivity was <0.5 S m⁻¹.

Concentrations of WSOC were determined by extracting a compost sample with DDW (water to solid ratio of 10:1 on an oven-dry basis) for 2 h in a horizontal shaker at room temperature. The suspension was then centrifuged at 9630 × g for 10 min and filtered through a 0.45-μm membrane filter after first filtering through a Fisher G8 glass fiber filter (Whatman, Kent, UK). The filtrates were then analyzed for total WSOC using a Shimadzu (Columbia, MD) TOC-5050A.

Statistical Analyses

The SAS program was used to detect statistically significant differences ($P < 0.05$) between treatments (SAS Institute, 1987). Effects of two main factors (samples and storage methods) were tested using a GLM procedure. Duncan's Multiple Range Test was used to calculate the significance of difference among storage treatments for each sample. Correlation coefficients were calculated among the three parameters using a CORR procedure.

Table 3. Cumulated CO₂ evolution of fresh, air-dry, and frozen compost samples after 7 d.†

Sample	Fresh	Air-dry	Frozen
	g CO ₂ kg ⁻¹ dry matter h ⁻¹		
Register-1	136.49 ± 0.92a‡	49.17 ± 3.23b	0.51 ± 0.51c
Register-2	85.00 ± 4.11a	31.90 ± 1.05c	37.03 ± 0.71b
Register-3	38.57 ± 0.64a	21.93 ± 0.51b	14.45 ± 0.10c
Winslow-1	11.90 ± 0.73a	8.69 ± 0.36b	3.47 ± 0.20c
Winslow-2	4.52 ± 0.64b	9.74 ± 0.63a	2.82 ± 0.15c
Winslow-3	3.68 ± 0.78a	5.38 ± 0.24a	4.56 ± 0.50a
Sunset-1	10.47 ± 0.25a	8.46 ± 0.21b	6.60 ± 0.64b
Sunset-3	10.38 ± 0.19a	7.33 ± 0.26b	7.78 ± 0.52b
Sunset-5	4.49 ± 0.78a	4.42 ± 0.06a	5.62 ± 0.12a
Meadow-1	2.17 ± 0.18b	4.72 ± 0.39a	2.28 ± 0.05b
Meadow-2	1.31 ± 0.61a	2.28 ± 0.21a	1.06 ± 0.05a
Overall means	28.14 ± 43.81a	14.06 ± 14.59b	7.87 ± 10.41c

† Measurements were taken at 24 ± 2°C and 60% of moisture content in the lab during a period of incubation for 14 d.

‡ One standard deviation of three replicates; means of different treatments on each sample (same row) that are followed by the same letter are not significantly different ($\alpha = 0.05$) using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Compost samples varied greatly in their physical and chemical properties (Table 1). Compost stability and maturity also varied greatly among samples from different facilities (Fig. 1, Tables 2–5). In general, Register samples were the least stable and mature (e.g., high in CO₂ evolution rate and WSOC and low in seed germination). There was no apparent linear relationship found between the physical and chemical properties of a fresh sample and corresponding compost stability and maturity.

Carbon Dioxide Evolution Rate

The CO₂ evolution rate fluctuated during the incubation (Fig. 1). Less-stable compost exhibited greater variations over time and formed obvious peaks of CO₂ evolution (Register-1 and Register-2 samples), which were previously reported (Hue and Liu, 1995; Iannotti et al., 1994; Lasaridi and Stentford, 1998). As a result, the average CO₂ evolution or the total CO₂ evolution for 3 d has often been used to represent compost stability. However, the 3-d cutoff could not be used in the present study because the time to reach the maximum CO₂ activity was affected by the storage method for some samples. For example, the fresh Register-1 sample took about 3 to 4 d to reach its peak CO₂ evolution rate, while the air-dried and frozen samples took about 4 to 5 and 7

Table 4. Seed germination rates measured in fresh, air-dry, and frozen stored samples.

Sample	Fresh	Air-dry	Frozen
	% of water as control		
Register-1	7 ± 12†a	9 ± 2a	2 ± 2a
Register-2	41 ± 18b	65 ± 16a	46 ± 20ab
Register-3	79 ± 10a	79 ± 17a	82 ± 0a
Winslow-1	90 ± 10a	90 ± 7a	63 ± 13a
Winslow-2	97 ± 4a	90 ± 6a	88 ± 9a
Winslow-3	95 ± 8a	89 ± 4a	96 ± 3a
Sunset-1	52 ± 6b	89 ± 9a	82 ± 9a
Sunset-3	31 ± 8b	84 ± 11a	87 ± 6a
Sunset-5	41 ± 8b	86 ± 12a	72 ± 8a
Meadow-1	89 ± 9a	85 ± 10a	88 ± 10a
Meadow-2	87 ± 5a	89 ± 12a	89 ± 8a
Overall means	66 ± 31c	77 ± 23c	72 ± 27b

† One standard deviation of three replicates; means of different treatments on each sample (same row) that are followed by the same letter are not significantly different ($\alpha = 0.05$) using Duncan's Multiple Range Test.

Table 5. Water-soluble organic carbon (WSOC) concentration of freshly collected, air-dry, and frozen stored samples.

Sample	Fresh	Air-dry	Frozen
	g kg ⁻¹ dry matter		
Register-1	38.2 ± 0.1a†	29.7 ± 0.3b	38.6 ± 0.3a
Register-2	29.8 ± 1.9b	27.2 ± 1.8c	35.2 ± 0.1a
Register-3	23.5 ± 0.2b	19.2 ± 1.9c	25.3 ± 0.1a
Winslow-1	8.1 ± 0.7b	6.8 ± 0.2c	9.7 ± 0.3a
Winslow-2	7.9 ± 0.3b	6.5 ± 0.7c	9.2 ± 0.3a
Winslow-3	5.3 ± 0.3b	3.5 ± 0.1c	6.5 ± 0.2a
Sunset-1	20.5 ± 0.7b	13.3 ± 0.8c	21.7 ± 1.1a
Sunset-3	19.1 ± 0.5b	13.2 ± 1.6c	23.0 ± 1.2a
Sunset-5	15.0 ± 0.2b	10.5 ± 0.0c	14.4 ± 1.0a
Meadow-1	0.8 ± 0.0a	0.6 ± 0.5a	0.7 ± 0.2a
Meadow-2	0.3 ± 0.0a	0.4 ± 0.1a	0.3 ± 0.1a
Overall means	15.7 ± 12.0c	11.9 ± 10.0b	16.8 ± 13.0a

† One standard deviation of three replicates; means of different treatments on each sample (same row) that are followed by the same letter are not significantly different ($\alpha = 0.05$) using Duncan's Multiple Range Test.

to 9 d, respectively (Fig. 1). Samples such as frozen Register-1 (Tables 2 and 3) that take longer to reach peak CO₂ evolution will inevitably have lower accumulated CO₂ evolution, thus giving misleading results. For more stable compost samples, the overall CO₂ evolution rate was much lower and exhibited no clear trend of peaking (Fig. 1). This implies that there is no advantage in using peak CO₂ evolution versus accumulated CO₂ evolution for more stable compost. In other words, for more stable compost, either determination will provide valid data for evaluating compost stability. The delay in peaking and changed peak shapes of CO₂ evolution in the active samples are probably the results of changes of microbiology of the stored sample. The difference between active and stable sample is probably because the more active samples have more active microbes that are more sensitive to freezing and air-drying than less active ones (MacLeod and Calcott, 1976).

Seed Germination

With the exception of the Sunset samples, no significant storage effect was noted in the seed germination test for the compost samples. For the Sunset compost samples, both air-drying and freezing storage significantly ($p < 0.01$) increased the seed germination, which is difficult to explain (Table 4). Many of the substances found in immature compost can result in a reduction in the seed germination rate, with its magnitude depending on the source waste material and composting process. For example, a variety of organic compounds, including short- (Shiralipour et al., 1997) and long-chain fatty acids (Sesay et al., 1997) and phenolic acids (Levimiñzi et al., 1994; Ishii and Kadoya, 1993; Janovicek et al., 1997) inhibit seed germination. However, many of these substances could coexist in immature compost. It has been discovered that a combination of volatile acids in an extract of an immature compost was phytotoxic to lettuce (*Lactuca sativa* L.) seedlings at concentrations far lower than the minimum levels at which individual acids such as formic, acetic, benzoic, salicylic, and tannic acids exerted any deleterious effects (Manios et al., 1987). The Sunset samples were very fibrous, containing large amounts of sawdust, and were in general different physically and chemically from the other samples. So the increase in seed germination for the Sunset samples is probably related to the source material or its composting process. On the other hand, Register was the only group that showed a clear trend of maturation with curing, and samples in this group exhibited consistent and comparable seed germination inhibition among the different storage treatments (Table 4). The results from the Register group demonstrate that proper storage does not significantly alter the phytotoxic properties of an immature compost.

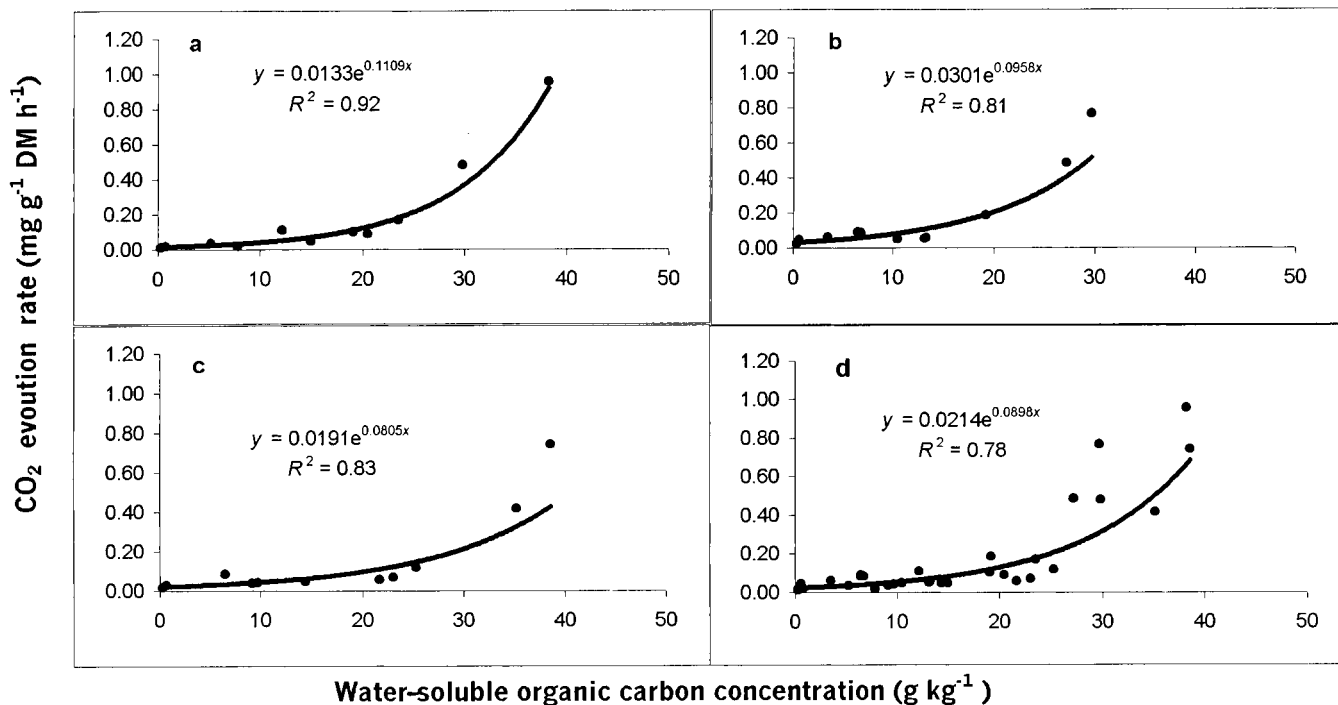


Fig. 2. Relation between compost water-soluble organic carbon (WSOC) and peak CO₂ evolution rate of (a) fresh samples; (b) air-dry samples; (c) frozen samples; (d) all samples. DM = dry matter.

Water-Soluble Organic Carbon

Water-soluble organic carbon was more affected by the storage treatments than CO₂ evolution and seed germination tests. Except for the most stable Meadow samples, air-dry storage significantly reduced the amount of WSOC, whereas frozen storage significantly increased the WSOC concentration (Table 5). The reduction in WSOC for the air-dried samples could be due to loss of volatile organic acids. The freezing–thawing process has been reported to enhance the water extractability of soil organic carbon due to disruptions in the physical structure of soil samples and release of microbial cell contents when the cell wall is ruptured by ice formation (Winter et al., 1994).

Relation of Water-Soluble Organic Carbon to Carbon Dioxide Evolution and Seed Germination

Despite the inconsistency of storage effects on the three measured parameters, there was high correlation between the parameters. Peak CO₂ evolution rate was exponentially related to WSOC with $R^2 = 0.92$ (<0.01 , $n = 11$), 0.81 (<0.01 , $n = 11$), and 0.83 (<0.01 , $n = 11$) for the fresh, air-dried, and frozen samples, respectively (Fig. 2). The coefficient of determination (R^2) between CO₂ evolution rate and WSOC for all samples was 0.78 (<0.01 , $n = 33$). Water-soluble organic carbon was also linearly correlated with the seed germination rate. The coefficient of determination between WSOC and seed germination rate was 0.67 (<0.01 , $n = 11$), 0.53 (<0.01 , $n = 11$), and 0.54 (<0.01 , $n = 11$) for fresh, air-dry, and frozen samples, respectively, while that of all the samples was 0.57 (<0.01 , $n = 33$) (Fig. 3). The similar R^2 with or without sample storage indicates that consistent

relationships exist between WSOC, CO₂ evolution, and seed germination, and that the relationships are not seriously affected by sample storage.

A significant decrease in WSOC concentration during composting and maturation was observed and WSOC was suggested as a potential indicator of compost stability and maturity in other studies (Chefetz et al., 1998; Garcia et al., 1991a,b; Hue and Liu, 1995; Inbar et al., 1993). Although no other data on the relationship of compost respiration rate and WSOC are available, it is generally believed WSOC is the most labile portion of organic carbon and provides a direct carbon source for microbial growth (Boyer and Groffman, 1996). In a similar study, Pascual et al. (1997) found that the germination index and plant root length were negatively correlated with WSOC based on several urban wastes of different natures and levels of organic matter stability.

SUMMARY

Depending on the stability and maturity level of the compost and on the compost feedstock source, air-drying and freezing samples had varied effects on the three measured parameters: CO₂ evolution rate, seed germination rate, and WSOC concentration. Neither of the two storage methods is satisfactory in terms of maintaining the original properties of the fresh compost. Storage tends to delay the peaking of CO₂ evolution rate of the active sample, causing much lower accumulated CO₂ evolution during a fixed period of time. Peak CO₂ evolution rate, rather than average or total CO₂ evolution over time, was thus a more suitable parameter for evaluating compost stability for compost of high microbial activity. It is possible to preserve compost samples for phytotoxicity analysis. However, fresh sam-

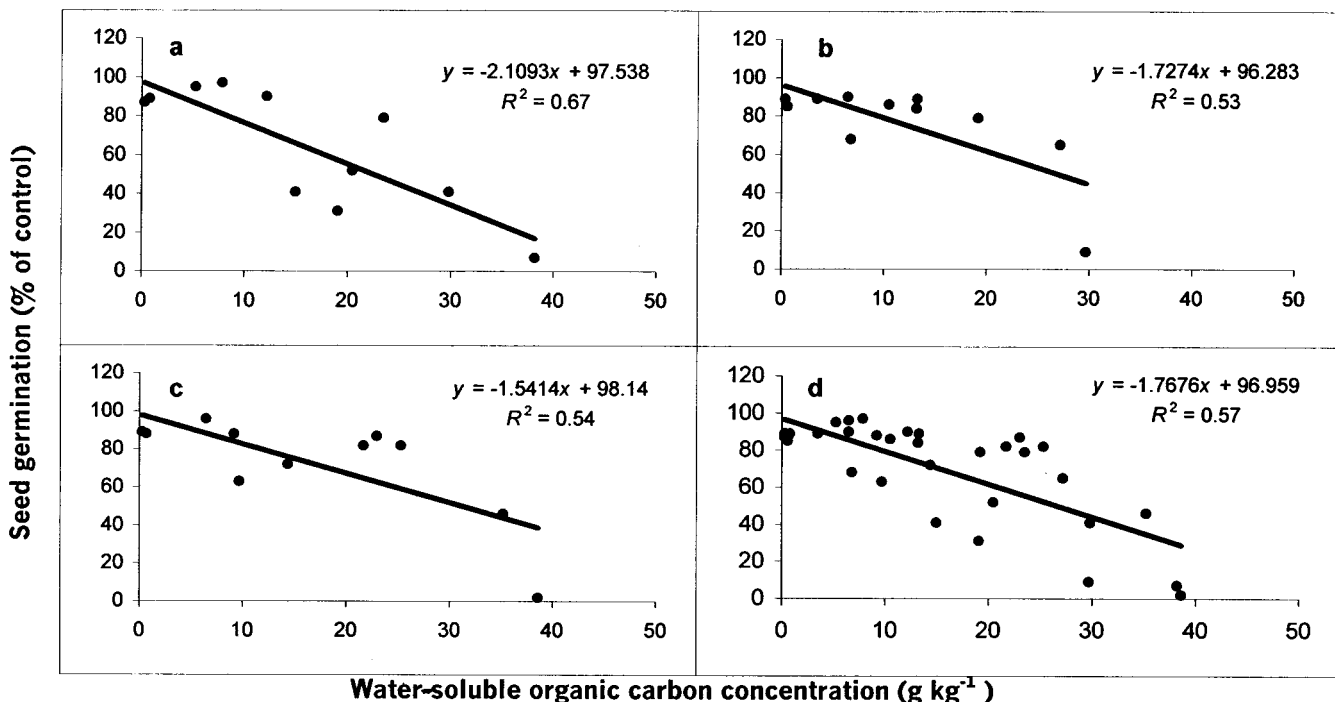


Fig. 3. Relation between compost water-soluble organic carbon (WSOC) and tomato seed germination of (a) fresh samples; (b) air-dry samples; (c) frozen samples; (d) all samples.

ples without storage are recommended for phytotoxicity test before the storage effect is further understood. The WSOC concentrations decreased with air-dry storage and increased with frozen storage. The storage effect was not significant on compost with low initial WSOC. Despite all these variations, WSOC has a significant and consistent correlation with both CO₂ evolution and seed germination.

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